Conversion Factors

Area

1 square foot	= 144 square inches
1 square yard	= 9 square feet
1 square mile	= 640 acres or 1 section
1 square meter	= 10.764 square feet
1 square meter	= 10,000 square centimeters
1 acre	= 43,560 square feet
1 hectare	= 2.471 acres

Length

1 inch	= 2.54 centimeters	= 25.4 millimeters
1 foot	= 12 inches	= 0.305 meters
1 yard	= 3 feet	= 0.914 meters
1 mile	= 5,280 feet	= 1,760 yards
1 meter	= 39.37 inches	= 3.281 feet
1 kilometer	= 0.621 miles	= 1,000 meters

Power1 horsepower= 0.746 kilowatts1 horsepower= 33,000 ft-lbs/minute1 kilowatt= 1,000 watts

Volume

1 cubic foot	=	1,728 cubic inches			
1 cubic foot	=	7.48 gallons			
1 cubic yard	=	27 cubic feet			
1 acre-inch	=	27,152 gallons			
1 acre-foot	=	43,560 cubic feet			
1 acre-foot	=	326,000 gallons*			
1 gallon	=	3.785 liters			
1 gallon	=	231 cubic inches			
1 gallon	=	4 quarts			
1 cubic meter	=	35.318 cubic feet			
1 cubic meter	=	1.308 cubic yards			
1 liter	=	0.2642 gallons			
1 liter	=	1,000 milliliters			
*rounded off to nearest thousand gallons					

Flow1 cubic foot/second= 449 gallons/minute1 gallon/second= 0.134 cubic feet/second1 gallon/second= 8.021 cubic feet/minute1 gallon/minute= 0.00223 cubic feet/second1 gallon/minute= 1,440 gallons/day

Pressure

1 foot of water per square inch	=	0.434 pounds
1 pound per square inch	=	2.307 feet of water
1 pound per square inch	=	2.31 feet of water

Weight

1 gallon	=	8.34 pounds of water
1 cubic foot	=	62.4 pounds of water
1 pound	=	0.454 kilograms
1 kilogram	=	1,000 grams
1 liter	=	1,000 grams
1 mg/kg or 1 ppm or 1 mg/L	=	0.0022 pounds/ton or 0.0001%
1%	=	10,000 mg/L
1 mg/L	=	1,000 μg/L

3.14

Wastewater Formulas & Conversion Factors





Published by

MINNESOTA POLLUTION CONTROL AGENCY

520 Lafayette Road North St. Paul, Minnesota 55155-4194 wq-wwtp8-03

Metric System

The metric system is a decimal system based on units of tens – similar to our currency. If you think of the dollar as the basic unit, we can break it down this way:

- Dime = 0.10 dollars
- Cent = 0.01 dollars
- Mill (used in levying taxes) = 0.001 dollars

Occasionally we may want an extremely small (*micro*) number. If we want to talk about larger amounts – like 1000 watts of electricity – we use the prefix *kilo* (kilowatt). And sometimes we may need an extremely large (*mega*) number.

The metric system has three basic units of measurement:

- Length is measured in meters.
- Volume is measured in liters.
- Weight (mass) is measured in grams.

Like dollars, each can be broken into smaller units and expanded into larger units as shown in Table 1. (The most commonly used units are bolded.)

	Table 1: Comparing the Metric System				Basic Unit		
	0.000001	0.001	0.01	0.1	1	1,000	1,000,000
		Mill	Cent	Dime	Dollar		
					Watt	Kilowatt	
Prefix:	Micro	Milli	Centi	Deci		Kilo	Mega
Prefix:	Micro Micrometer	Milli Millimeter	Centi Centimeter	Deci Decimeter	Meter	Kilo Kilometer	Mega Megameter
Prefix:	Micro Micrometer Microliter	Milli Millimeter Milliliter	Centi Centimeter Centiliter	Decimeter Deciliter	Meter Liter	Kilo Kilometer Kiloliter	Mega Megameter Megaliter

One other useful term is a measurement of area. A square of land measuring 100 meters by 100 meters is called a *hectare*, after the prefix for 100 – *hecto*.

Table 2: Prefixes used in the Metric System

Prefix	Meaning				
Micro	0.000001	(1/1,000,000)			
Milli	0.001	(1/1,000)			
Centi	0.01	(1/100)			
Deci	0.1	(1/10)			
Deka	10				
Hecto	100				
Kilo	1,000				
Mega	1,000,000				

Trivia:

- A centimeter is about the width of your little finger.
- The "hand" (used for measuring horses) is about 10 centimeters, or a decimeter.
- By the original definition of the meter in the eighteenth century, the circumference of the earth is 40 megameters.

Symbols

π	= pi or 3.14
/	= per (as gallons/day)
%	= percent
μ L	= microliters

Abbreviations

A	=	area	hr	=	hour
ac-ft	=	acre-feet	HRT	=	hydrauli
В	=	base	in	=	inch
С	=	circumference	in ²	=	square ir
°C	=	degrees Centigrade	in ³	=	cubic ind
CBOD	=	carbonaceous	L	=	length o
		biological oxygen	lb	=	pound
		demand	mi	=	mile
CEC	=	cation exchange	mi ²	=	square n
		capacity	min	=	minute
cfm	=	cubic feet per minute	mg	=	milligrar
cfs	=	cubic feet per second	mg/kg	=	milligrar
cu in	=	cubic inches or	mg/L	=	milligrar
		inches ³	Mgal o	r	
cu ft	=	cubic feet or feet ³	MG	=	million g
D	=	diameter	MGD	=	million ga
ft	=	foot or feet	ml	=	milliliter
ft ²	=	square feet	MLSS	=	mixed lie
ft ³	=	cubic feet			solids
°F	=	degrees Fahrenheit	MLVSS		mixed liq
F/M	=	food to mass ratio	N	_	suspend
gal	=	gallons		_	introgen
gal/mi	n =	gallons per minute	INH ₃ -IN	= ;	ammonia
gal/see	c =	gallons per second		=	nitrato
GPD	=	gallons per day	Ora N	_	organicu
GPM	=	gallons per minute	D D	_	nerimet
GPS	=	gallons per second	PF	_	nonulati
Н	=	height	.∟ ni or π		7020100 3 14
					J.1 T

Symbols & Abbreviations

	ppb	= parts per billion
aulic retention time	ppm	= parts per million
	psi	= pounds per square
re inch		inch
inch	Q	= flow
h or liter	R	= radius
d	RAS	= return activated sludge
u	rise	= vertical distance or height
re mile	RPM	= revolutions per
te		minute
jrams	run	= horizontal distance or
jrams per kilogram		length
jrams per liter	S	= side of a rectangle
	sec	= seconds
on gallons	sq in	= square inches
n gallons per day	sq ft	= square feet
iters	SVI	= sludge volume index
d liquor suspended	SRT	= solids retention time
5	SS	= suspended solids
liquor volatile	TKN	= Total Kjedahl Nitrogen
ended solids	TSS	= total suspended solids
gen	V or v	ol = volume
onia nitrogen	vel	= velocity
	W	= width
5	WAS	= waste activated sludge
nic nitrogen	yd	= yard
neter	yr	= year
lation equivalent		

Stabilization Ponds/Spray Irrigation

Stab. ponds/ Spray Irrig.

Organic Loading on Primary Cell(s) (pounds per day per acre) =

influent BOD (mg/L) x flow (MGD) x 8.34 lbs/gallon

total surface area of primary(s) (acres)

Storage Volume of a Pond (gallons) =

average surface area (acres) x depth (feet) x 326,000 gallons per acre-feet

Volume of Pond Discharged (gallons) = depth discharged (feet) x pond size (acres) x 326,000 gallons per acre-feet

Discharge Flow Rate (gallons per day) = depth discharged in one day (feet per day) x pond size (acres) x 326,000 gallons per acre-feet

Detention Time = volume of pond between maximum and minimum depth flow rate

Total Feet Needed to Discharge or Spray:

1. Storage volume needed (acre-feet) = flow rate (gallons per day) x storage time needed (days) 326,000 gallons per acre-feet

- 2. Storage volume available (acre-feet) = [maximum depth (feet) – actual depth (feet)] x size of pond (acres)
- 3. Total volume needed to discharge or irrigate (acre-feet) = storage volume needed (acre-feet) - storage volume available (acre-feet)
- 4. Total feet needed to discharge or spray (feet) =

240

total volume needed to discharge or spray (acre-feet) size of pond being discharged or sprayed (acres)

Digestion

Digestion

Volatile Acid/Alkalinity Ratio = volatile acids concentration (ml/L) alkalinity concentration (ml/L)
Total Solids Loading (lbs/day) = percent total solids x raw sludge (gal/day) x 8.34 (lbs/gal)
100
Volatile Solids Loading (<i>lbs/day</i>) = percent volatile solids x total solids loading (<i>lbs/day</i>)
100
Volatile Solids Loading (lbs VS/cu ft of digester capacity) = volatile solids loading (lbs/day) digester volume (cu ft)
Dry tons = gallons x percent total solids



The Perimeter (P) is the sum of the four Sides (S).

diameter radius

The Circumference (C) is Diameter (D). (The diameter is two times the radius: $D = 2 \times R$)



The Area (A) is equal to the Length (L) times the Width (W).

 $(D = 2 \times R)$





The Area (A) of a triangle is equal to the length of the Base (B) times the Height (H) divided by 2.

©2017, State of Minnesota, Minnesota Pollution Control Agency All rights reserved.

Perimeter /Circumference

Rectangle or Square $P = S_1 + S_2 + S_3 + S_3$



	Circle
s <i>pi</i> (π, 3.14) times the	$C = \pi \times D$



Area (A) of a circle is equal to 0.785 times the	
Diameter squared (D ²).	
Area (A) of a circle is also equal to $pi(\mathbf{\pi}, 3.14)$	
times the <i>Radius squared</i> (R ²).	
Remember: the diameter is 2 times the radius	
$(D - 2 \times B)$	

Circle

 $A = 0.785 \times D^2$ $A = \pi \times R^2$

> Triangle $A = B \times H$ 2

Volume

Volume

=

Rectangle V = A x H V = L x W x H	The Volume (V) of a rectangle equals its Area (A) times its Height (H). Since the Area (A) of a rectangle is its Length (L) times its Width (W), Volume (V) can also be expressed as Length (L) times Width (W) times Height (H).	length width	Hydraulic Loading Rate (HLR – in gallons per day per square foot) Organic Loading Rate (OLR – in pounds per day per 1,000 sq ft) =		
Cylinder V = Area x H $V = 0.785 x D^2 x H$ or $V = \pi x R^2 x H$	 The Volume (V) of a cylinder equals its Area (A) times its Height (H). Since its Area (A) equals 0.785 times the Diameter squared (D²), Volume (V) equals 0.785 times the Diameter squared (D²) times its Height (H). Remember: the diameter is 2 times the radius (D = 2 x R) Note: 0.785 comes from dividing π by 4 when you use diameter instead of radius. 	height diameter	Organic Loading (in pounds per day per 1,000 cubic feet) = <u>CBOD con</u> aeration Food to Mass Ratio (F/M) = <u>CBOD concentration</u> <u>MLVSS concentration</u> *Note: CBOD conc Sludge Volume Index (SVI) = <u>30-minute sludge set</u> ML		
Cone $V = \frac{A \times H}{3}$ $V = \frac{0.785 \times D^2 \times H}{3}$	The Volume (V) of a cone equals its Area (A) times its Height (H) divided by 3. Since its Area (A) equals 0.785 times the Diameter squared (D ²), Volume (V) equals 0.785 times the Diameter squared (D ²) times its Height (H) divided by 3. Remember: the diameter is 2 times the radius ($D = 2 \times R$)	height diameter	SRT (Solids Retention Time) = MLVSS concentration (mg/L) x total [waste sludge conc (mg/L) x waste sludge flow (MGD) x 8.34 lb, **of aeration tank and cl Wasting Rate (lbs/day) = MLVSS in aeration tank and SRT (days) Return Rate (MGD) = Total flow (MGD) x MLSS conc RAS conc (mg/L) – MLSS		
To convert volume from cubic feet to gallons: multiply cubic feet x 7.48 gallons per cubic feet					

If using goal posts to convert cubic feet to gallons, use the factor 7.48 gallons

cubic ft

Rotating Biological Contactors

flow rate (gallons/day) total surface area of media (square feet)

pounds/day applied to RBC total surface area of media (in 1,000 sq ft units)

Activated Sludge

centration (mg/L) x flow (MGD) x 8.34 lb/gal tank volume(in 1,000 cubic feet units)

1* (mg/L) **x flow** (MGD) **x 8.34** *lb/gal* (mg/L) x aeration tank volume (MG) x 8.34 lb/gal centration entering aeration tank

ttleability reading (ml) x 1,000 LSS (mg/L)

volume** (MG) x 8.34 lb/gal /gal] + [effluent TSS conc (mg/L) x flow (MGD) x 8.34 lb/gal] larifier

d clarifier (lbs) – TSS lost (lbs/day)

centration (mg/L) conc (mg/L)

Gal/day to MGal/day

To convert gallons/day to million gallons per day: **Million Gallons/Day** (MGD) = gallons/day 1,000,000

Gal/day to MGal/day

Activated Sludge

Rotating Bio. Contactors

Solids

Solids

Total Solids (%) = weight of dry sludge x 100 weight of wet sludge

Total Suspended Solids (mg/L) = weight of suspended solids (mg) volume of sample (liter)

Volatile Solids (%) = weight of material lost by burning x 100 weight of dry sludge

Volatile Suspended Solids (mg/L) = weight of material lost by burning (mg) volume of sample (liter)

Organic Nitrogen = Total Kjeldahl Nitrogen (TKN) – Ammonia Nitrogen

Clarifiers

Surface Settling Rate (SSR) = flow rate surface area

Weir Overflow Rate (WOR) = ______flow rate weir length

Detention Time (DT) = volume of tank flow rate to or from tank

Percent Removal (PR%) = <u>influent - effluent x 100</u> influent

Trickling Filter

Clarifiers

Hydraulic Loading Rate (HLR) = total flow to filter* surface area of filter (*where total flow = influent flow + recirculation flow)

Organic Loading Rate (OLR) = pounds pe

pounds per day applied to the filter volume of filter media (in 1,000 cubic feet units)

Recirculation Ratio (RR) = Recirculated flow Influent flow

(OLR – in pounds per day per 1,000 cu ft)



Slope equals the *Rise or Drop* (elevation) divided by the *Run* (distance).



To get the *Percent Slope* (Slope %), multiply the *Rise/Run* by 100.

To change Fahrenheit to Celsius:

- Subtract 32 from the Fahrenheit temperature
- Divide the answer by 9.
- Multiply that answer by 5.

To change Celsius to Fahrenheit:

- Multiply the Celsius temperature by 9.
- Divide the answer by 5.
- Add 32.

Slope

Slope

Slope = Rise (or drop) Run

Slope (%) = <u>Rise</u> x 100 Run

 $\frac{\text{Rise} = \frac{\text{Slope (\%)}}{100} \text{ x Run}$

Velocity/Flow Rate

Velocity = Distance traveled Time

 $Velocity = \frac{Flow rate}{Area}$

Flow rate = Velocity x Area

Temperature

: nheit temperature

 $^{\circ}C = (^{\circ}F - 32) \times \frac{5}{9}$

:: rature by 9.

 $^{\circ}\mathsf{F} = \left(^{\circ}\mathsf{C} \times \frac{9}{5} \right) + 32$

Detention Time

Detention Time =

volume of tank flow rate to or from tank **Detention** Time

Temperature

Pumping Rate & Power

Pumping Rate & Power

Pumping Rate = volume pumped time pumped

Pumping Rate_{PISTON PUMP} (gal/min) =

volume displaced (gallons) by one piston stroke x number of piston strokes time for above number of strokes (minutes)

Pumping Rate_{CALIBRATED} (gal/min) =

drawdown volume (gallons) refill volume (gallons) + time to drawdown wet well (minutes) time to refill wet well (minutes)

Reminder: Divide before you add!

Water Horsepower = Flow (gallons per minute) x Total dynamic head (feet) 3,960

Brake Horsepower = Water horsepower

Pump efficiency*

* Expressed as a decimal, i.e., 85% = .85

Note: Horsepower = kilowatts x 1.34 Kilowatts = horsepower x 0.75

Total Static Head (feet) = Static discharge head (feet) + Static suction head (feet)

Total Dynamic Head (feet) = Total static head (feet) + System friction loss or head (feet)

Chlorination & Chemicals

nlorination Chemicals

Chlorine Dosage (mg

/L) = chlorine demand (mg/L) +	chlorine residual (mg/L)



Feed Rate $(lb/day) = dosage (mq/L) \times flow (million gallons/day) \times 8.34 (lb/gallon)$

Chemical Dosage (lbs) = Concentration (mg/L) x Volume (MG) x 8.34 (lb/gallon)

Detention Time = volume of tank flow rate to or from tank

Percent Removal

Percent Removal (%) = influent - effluent x 100 influent

Table 3: Conversion of Numbers Multiplied to Its' Inverse				
Numbers multiplied	Inverse	To 1.		
2	0.500			
3	0.333			
4	0.250	2.		
5	0.200	3.		
6	0.167			
7	0.143			
8	0.125			
9	0.111			
10	0.100			
11	0.091			
12	0.083			
13	0.077			

0.071

0.067

14

15

- maximum number.)
- Multiply all numbers.

- If you multiplied **two numbers**: push the square root key once; answer shown is the GM.
- If you multiplied **four numbers**: push the square root key twice; answer shown is the GM.
 - answer shown is the GM.

Loading (lb/day) = concentration (mg/L) x flow (million gallons/day) x 8.34 lb/gallon

Loading (kg/day) = **concentration** $(mg/L) \times$ **flow** $(million gallons/day) \times 3.78 kg/gallon$

Loading_{ORGANIC} (*lb/day*) = population (*people*) x population equivalent factor (*lb/person/day*)

 $Loading_{HYDRAULIC}$ (gal/day) =

Table 4:	Popula
Рор	ulatior
BOD	0.1
TSS	0.2
Flow	100 g

Loading (*lbs*) = Concentration (mq/L) x Volume (million gallons) x 8.34 *lb/gallon*

Loading (Ibs) = Percent solids (expressed as a decimal) x Volume (gal) x 8.34 lb/gallon

Loading_{VOLATILE SOLIDS} (*Ibs*) = *expressed as a decimal

©2017, State of Minnesota, Minnesota Pollution Control Agency All rights reserved.

Removal

Geometric Mean

Loading

calculate the Geometric Mean (GM):

Change all single digit "0" to "1"; drop all "<" symbols; and count the number of values you have. (For any "TNTC" values, contact lab for

Use one of these methods to find the Geometric Mean:

If you multiplied three or more than four numbers:

push the y^{X} or x^{Y} or key , then enter the inverse of the number of values you multiplied (see Table 3). Finally, push the = key;

population (people) **x population equivalent factor** (gal/person/day)

tion equivalent factors

equivalent factors

17 lb/person/day

20 lb/person/day

gallons/person/day

Total solids* x Volatile solids* x Volume (gal) x 8.34 lb/gallon

oading